

[54] **NOVEL CUTTING EDGES AND PROCESSES
FOR MAKING THEM**

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[57]

ABSTRACT

Novel cutting edges and especially razor blades which have substantially better corrosion resistance, edge hardness, temper resistance, strength and ductility than those heretofore made from stainless steel and processes for making such cutting edges. Generally the cutting edges are formed from alloys comprising 30 to 60 percent cobalt, 10 to 40 percent nickel, 15 to 25 percent chromium and 5 to 12 percent molybdenum by (a) heating strips of such alloys under conditions which will result in said strips having a face centered cubic structure when cooled to room temperature, (b) cold working the strips, (c) age hardening the strips and (d) at some time during or subsequent to the cold-working step and before or after the age hardening step forming the cutting edge therein.

10 Claims, No Drawings

NOVEL CUTTING EDGES AND PROCESSES FOR MAKING THEM

Although cutting edges such as razor blades at first glance appear to be fairly simple instruments, they are in reality delicate and complex. With razor blades the ultimate edge is generally in the order of 250 angstroms thick and because of such dimensions they are extremely sensitive to the slightest amounts of corrosion. Further the edges are hardened to the highest extent achievable but yet it is necessary that they retain sufficient strength and ductility to withstand the stresses and strains such a narrow edge is subjected to during the source of its use. Further in addition to all this, it is necessary that they have good temper resistance to withstand the high temperatures which they are usually subjected to when the polytetrafluoroethylene coatings which are generally applied to them are sintered thereon. Although stainless steels have filled some of these requirements to a fair degree there is substantial room for improvement.

One object of the present invention is to provide novel cutting edges and especially razor blades which have hardnesses, stress corrosion resistances, ductilities, strengths and temper resistances which are substantially better than those of stainless steel.

Another object of the present invention is to provide processes for making such edges.

Other objects should be obvious from the following description and claims.

In general, the aforementioned objects are achieved by: (a) heating an alloy comprising nickel, cobalt, chromium and molybdenum in the ranges specified below under conditions which will result in the alloy having a well annealed single phase face centered cubic structure when it is cooled to room temperature; (b) cold working the single phase alloy; (c) age hardening the alloy and at some time during or subsequent to cold working step and before or after the age hardening step forming the cutting edge. In a preferred mode of making cutting instruments such as razor blades, the cutting edge is formed; e.g., by grinding subsequent to the age hardening step.

Generally the blades of the present invention are made from alloys which comprise by weight about 10 to 40 percent nickel, 30 to 60 percent cobalt, 15 to 25 percent chromium, 5 to 12 percent molybdenum, and 0 to 20 percent iron. In preferred embodiments, the alloys comprise 20 to 35 percent nickel, 20 to 45 percent cobalt, 15 to 25 percent chromium, 5 to 12 percent molybdenum and 0 to 5 percent iron. If desired, the alloys may contain other alloying elements which enhance the properties of the alloy but do not interfere with the processes. As examples of such other alloying elements and their preferred ranges mention may be made of the following:

Carbon	0 to 0.3%
Manganese	0 to 5%
Tungsten	0 to 3%
Copper	0 to 5%

In carrying out the processes of the present invention, the alloy is heated and held at a temperature such that the alloy will be a fully annealed single phase material having a face centered cubic crystal structure when it is cooled to room temperature, e.g., by air cooling or quenching. The temperature and the period of time the

alloy has to be held at such temperature in order to provide such a structure on cooling will vary depending upon the specific composition of the alloy. Metallurgists are quite familiar with this phenomena and will have little trouble ascertaining the best time and temperature for each particular material. Generally for most alloys within the scope of this disclosure, such a structure may be achieved by heating the alloy to a temperature of between 800°C to 1,200°C and holding it there for periods from at least 1 minute to 1 hour. It will be understood that the longer times will be used for lower temperatures and vice versa. In preferred embodiments, temperatures between 800°C and 1,050°C are employed. Particularly useful results were obtained by heating alloys to a temperature of 1,000°C for about one half hour.

The cold working step which converts the face centered cubic structure of the alloys to a close packed hexagonal structure and which imparts a substantial increase in hardness to the alloy, may be carried out by any of the well-known methods; e.g., rolling, stamping, pressing, drawing, etc. In preferred embodiments of the invention, the cold working is carried out by cold rolling. Generally a reduction in thickness between about 60 to 95 percent will provide the maximum hardening. It is to be understood that reductions somewhat below 60 percent and about 95 percent can be made, but the results will not be as dramatic as when the reduction is between 60 percent and 95 percent. The preferred reduction is between 75 to 95 percent. Preferably the cold working step is carried out under ambient conditions. However if desired it may be performed at temperatures below ambient temperature, e.g., down to that of liquid nitrogen or at elevated temperatures below the transition temperature of the alloy. Usually the transition temperature will vary with the amount of cobalt in the alloy. Generally with alloys comprising about 30 percent cobalt the cold working may be carried out at temperatures up to 250°C and with alloys comprising 60 percent cobalt it may be carried out at temperatures up to 650°C.

In using the processes of the present invention for producing cutting edges such as razor blades, the cold working may be provided at least in part by the grinding operation normally used in forming the cutting edge. Of course, it will be understood that if desired, substantially all the cold working may be carried out, for example, by cold rolling and the grinding step would contribute little additional hardening. In such event if desired, electro-sharpening methods may be employed in forming the cutting edge. The cutting edge may be formed prior to the age hardening step when the alloy is not as hard but in preferred embodiments, it is formed subsequent to the age hardening step when the alloy is appreciably harder. Generally, the methods which may be employed for forming the cutting edge are well known to the art and the specifics thereof form no part of this invention.

The age hardening step which is carried out subsequent to the cold working step is a time-temperature dependent reaction in which a further substantial increase in hardness is achieved. Generally the optimum hardness will be achieved by heating the alloy at temperatures between about 300°C and 700°C for periods, for example, of at least from about 1 minute to about 1 week. As will be appreciated, the shorter times will be more applicable to the higher temperatures and the

longer times to lower temperatures. With the alloy containing 35 percent nickel, 35 percent cobalt, 20 percent chromium and 10 percent molybdenum, optimum hardness was achieved by heating at 450°C for 3 hours and with the alloy containing 42.5 percent cobalt, 13 percent nickel, 20 percent chromium, 18 percent iron, 1.6 percent manganese, 2.8 percent tungsten, and 0.2 percent carbon, optimum hardness was achieved by heating at 450°C for 10 hours.

The following non-limiting examples illustrate the processes of the present invention as it relates to the preparation of a razor blade.

EXAMPLE 1

A sheet of alloy containing 35 percent nickel, 35 percent cobalt, 20 percent chromium, 10 percent molybdenum (weight percentages), and the usual trace of impurities found therein, was made to have a face centered cubic structure by heating it at 1,000°C for one half hour and thereafter air cooling it to room temperature. The sheet had a hardness of 200 DPHN. Part of the sheet was then cold rolled to a thickness of 0.004 inch with a reduction of 93 percent in the thickness of the alloy. The hardness after cold rolling was 540 DPHN. The strip was then sharpened to produce an edge through conventional razor blade sharpening techniques. Subsequent to sharpening, the blade was heated at 450°C for 3 hours and the body hardness rose to 725 DPHN. A polytetrafluoroethylene telomer coating was applied to the cutting edge and it was cured thereon at 343°C for 10 minutes. The following table illustrates the temper resistance of the blade of the present invention during the sintering step as compared with typical carbon and stainless steel blades.

Blade	Body hardness before sintering	Sintering Time & Temp.	Body hardness after sintering
Blades of Example 1	725 DPHN	343-10 min.	725
Carbon Steel Blades	825-880 DPHN	do.	510-560
Stainless Steel Blades (double edge type)	750	do.	580-595
Stainless Steel Blades (ribbon type)	750	do.	520-550

EXAMPLE 2

An alloy strip containing 42.5 percent cobalt, 13 percent nickel, 20 percent chromium, 2 percent molybdenum, 1.6 percent manganese, 2.8 percent tungsten, 18 percent iron, and 0.2 percent carbon and the usual impurities found therein was heated to 1,000°C for one half hour and thereafter cooled to room temperature to make it a single phase material having a face centered cubic structure. The strip with a hardness of around 220 DPHN was cold rolled until a reduction of 84 percent in thickness had been made and the strip had a thickness of 0.003 inch. The hardness was 521 DPHN. The strip was sharpened to produce an edge through conventional razor blade sharpening techniques. Subsequent to sharpening, the blade was heated to 450°C for 10 hours and the body hardness rose to 757 DPHN. A polytetrafluoroethylene coating was applied to the cutting edge and it was cured thereon at 343°C for ten minutes. Subsequent to the cure, the blade had a body hardness of 757 DPHN which is much better than that

of a typical carbon or stainless steel blade set forth in example 1.

In addition to the hardnesses and temper resistances set forth above, the blades of Examples 1 and 2 had strengths of approximately 300,000 pounds per square inch and sufficient ductility that they could be bent back on themselves (180°) without fracture. In a corrosion test at 70°F in a hydrochloric acid solution containing 10 percent sodium chloride, open crevice samples of the alloy of Example 1 corroded at the rate of 0.1 mil per year, whereas, 316 stainless steel corroded at the rate of 5 mils per year. In a 10 percent ferric chloride solution the results were even better in that the alloy of Example 1 remained intact while the 316 stainless steel corroded at the rate of over 50 mils per year. The corrosion resistance of the alloy of Example 2 was not as good as that of Example 1, but it was far superior to the stainless steel.

Having described the invention what is claimed is:

1. A process for making a cutting edge, said process comprising heat-treating a strip of an alloy consisting essentially of 30 to 60 percent cobalt, 10 to 40 percent nickel, 15 to 25 percent chromium and 5 to 12 molybdenum under conditions such that said strip will have a face centered cubic structure when it is cooled to room temperature, cold working the strip to convert the face centered cubic structure to a close packed hexagonal structure, age hardening the strip and at some time during or subsequent to the cold working step forming the cutting edge thereon.

2. A process as defined in claim 1 wherein said cutting edge is a razor blade.

3. A process as defined in claim 1 wherein said strip is cold worked so that there is a reduction in thickness of between 60 to 95 percent.

4. A process as defined in claim 1 wherein said heat treatment is carried out at a temperature of 800°C to 1,200°C for a period between 1 minute to 1 hour.

5. A process as defined in claim 1 wherein said age hardening is carried out at a temperature of 300°C to 700°C for periods of from 1 minute to 1 week.

6. A process as defined in claim 1 wherein said alloy is heat-treated at a temperature between 800°C to 1,200°C for a period of 1 minute to 1 hour, cold worked until there is a reduction in thickness of between 60 and 95 percent and age hardened at a temperature of 300° to 700°C for a period of 1 minute to 1 week.

7. A process as defined in claim 6 wherein said cutting edge is a razor blade.

8. A cutting edge of an alloy consisting essentially of 30 to 60 percent cobalt, 10 to 40percent nickel, 15 to 25 percent chromium, and 5 to 12 percent molybdenum, said alloy being in cold worked and age hardened condition and having a close packed hexagonal structure.

9. A cutting edge as defined in claim 8 which is a razor blade.

10. A razor blade as defined in claim 9 in which a polytetrafluoroethylene coating is on the cutting edge.

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